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Results of questionnaire surveys to determine the requirements in sciences and foreign languages in the curricula for high school biology teachers in certain teachers colleges, State colleges, and smaller State universities, and to identify the best teaching combinations with biology in terms of vacancies reported at placement bureaus of schools surveyed.

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HOW CAN THE CURRICULUM FOR HIGH SCHOOL BIOLOGICAL SCIENCE TEACHERS BE IMPROVED?

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THERE has been considerable discussion in the public press, by scientists, educators and government officials about the quality of science teaching. Much of the discussion has emphasized the need for higher teachers' salaries, additional classrooms and equipment, and other financial support.

Equally important, however, is an appraisal of the type of preparation secured by science teachers in our colleges and universities. The Biological Sciences have received less attention than the other sciences as they are considered less essential to the Defense Program than the physical sciences and mathematics.

This paper proposes, however, to consider only one aspect of the preparation of high school biology teachers: the curriculum. Other aspects of their preparation, course content, the quality of instruction, etc., although equally important, will be considered only in relation to the curriculum.

Several regional and national conferences have considered problems related to the biology curriculum and the preparation of high school biology teachers. Breukleman, et al. (1955) summarized the recommendations of the Southeastern Conference on Biology Teaching. They concluded that the curriculum should include a minimum of 24 semester hours in the biological sciences, including both botany and zoology and field studies, one year of chemistry, one year of physics, one-half year of earth science, and one year of mathematics. Mallinson (1957) in his summary of the Midwest Regional Conference on Science and Mathematics Teacher Education listed the following recommendations for the biological sciences: that there be a balance between botany and zoology; that the principle of selective admissions to the teacher preparation program be adopted; that most physical education courses not be recognized as the equivalent of courses in the biological sciences (coaches are often able to meet state certification requirements with a minimum of preparation in biology); and that biology teachers have "some" work in the physical sciences. Johnson et al. (1958) listed the following recommendations in a report on the proceedings of a conference sponsored by the National Academy of Sciences: that studies in the sciences for secondary school biology teachers should comprise not less than one-half of the undergraduate program; that one-fourth of the total undergraduate work be in the biological sciences; and one-fourth in the physical and earth sciences. Also, that it should be a "core program," and no more than 10 per cent of the work should be in a professional specialty elected by the student. They recommended that prospective biology teachers take as a minimum, two years of chemistry, one year of physics, and one year of mathematics; also field biology and methods of teaching biology.

Baker and Brooks (1957) made a survey of the preparation of high school teachers in Kansas in 1955–56. Their data shows that of 539 biology teachers, 53 per cent had no credit in general biology, 42 per cent had no botany, 34 per cent had no zoology, 87 per cent had no field biology, 32 per cent had no chemistry, and 42 per cent had no physics, and that 7.6 per cent of all biology teachers had no academic preparation in general biology, botany or zoology. They recommended that biology teachers should have preparation in the basic courses in botany, zoology and field biology, and that

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courses in health, foods, hygiene, nutrition, and farm crops are of secondary importance and should not satisfy the requirements for science teaching. Nelson (1956) surveyed the preparation of 63 high school biology teachers in Illinois. Their preparation in science ranged from 12 to 95.3 semester hours with a median of 47 semester hours. Fourteen of the 63 had no chemistry, 23 had no physics, 11 had no chemistry or physics, and 18 had less than a minor in biology. Nelson also indicated that the administrators in his sample ranked first the following statements appearing in the survey: "Training (of science teachers) spread over several science subject matter fields (physics, chemistry, biology, earth science, etc.) and in addition, intensive training in one field of science." They ranked second, "Sufficient training in several science fields . . . so that the teachers can give instruction in more than one science." Pella (1958) made a survey of the preparation of 367 biology teachers in Wisconsin. Only 2.8 per cent had no preparation in biology, 40.6 per cent had no physics, 20.2 per cent had no chemistry, 39.2 per cent had no earth science, and 24.6 per cent had no mathematics. The full-time biology teachers had more preparation in the sciences than did the part-time teachers. Crall and Myers (1958) made a survey of the requirements for the Master's degree for high school biology teaching. They recommended that the curricula for biology teachers be different from that for an administrator, that the graduate curriculum should aim toward the preparation of a "master teacher" and that it help the teacher to learn *what* to teach in addition to helping him learn *how* to teach.

NATURE OF THE PROBLEM

The study was begun early in 1958. It surveyed two problems by means of questionnaires: (1) What are the requirements in the sciences and foreign languages in the curricula for high school biology teachers in certain teachers colleges, state colleges and smaller state universities? and (2) What are the best teaching combinations with biology in terms of vacancies reported at the Placement Bureaus of these schools?

Letters explaining the purpose of the survey were sent to the heads of the departments responsible for the preparation of biology teachers in 90 colleges and universities from New York to California. A questionnaire on a posted, self-addressed post card was enclosed which made it convenient to prepare replies. A similar letter and post card were also sent to Placement Bureaus of the same schools.

Most of the schools contacted were either state teachers' colleges or state colleges whose main function is teachers preparation. Replies were received from 64 schools concerning curriculum requirements. Of these, 7 stated that they did not prepare biology teachers. Data obtained from 28 state colleges and universities and 29 state teachers' colleges were used in preparing this report.

Curriculum Requirements

The results obtained from the questionnaires are tabulated in Table I.

TABLE I

CURRICULUM REQUIREMENTS FOR A MAJOR IN BIOLOGY FOR HIGH SCHOOL BIOLOGY TEACHERS

(57 Colleges and Universities)

Subjects	No Requirements (No. of Schools)	Average Semester Hours in Schools Requiring These Courses
Botany	10	7.3
Zoology	8	7.8
Total in biological sciences	0	26.8
Chemistry	23	7.6
Physics	32	6.6
Geology	24	5.6
Mathematics	41	4.6
Foreign language	51	7.3
Mathematics, chemistry, and physics	20	—

These data indicate that there are wide variations in the curricula for high school biology teachers in the 57 colleges and uni-

versities. More than one-third do not require chemistry, over one-half do not require any physics, and comparatively few require mathematics or foreign language. Ten have no definite requirements in botany and eight do not require zoology. *Over a third do not require any chemistry, physics, or mathematics.* Nearly half do not require any geology (or earth science).

These data indicate that students preparing to become high school biology teachers in a large proportion of the schools included in this sample are *not required* to obtain a broad background in the physical sciences or mathematics, although a number of schools indicated that they recommend courses in these areas.

Teaching Combinations

A smaller response was obtained from the Placement Bureaus concerning the best teaching combinations with biology, and only 40 replies were received from the 90 schools contacted, and of these, 13 did not prepare biology teachers. It may indicate that the data requested was not readily available or that some schools do not have active Placement Bureaus. Analysis of the questionnaires was difficult because some schools did not give complete information, and some gave estimates. The results which can be considered only approximations, are shown in Table II.

These data indicate that the best teaching combinations based on data obtained from vacancies reported to Placement Bureaus, are biology alone, or biology combined with general science, physical science, coaching and mathematics. Over 60 per cent of the calls were for biology alone or in combination with general science or physical science. Combinations with social science, English, driver training and home economics and other courses not listed here are called for much less and a number of schools have no calls for them at all. The data also indicates that high school administrators frequently seek teachers who can coach. Perhaps this has become traditional.

TABLE II

TEACHING COMBINATIONS WITH BIOLOGY THAT ARE MOST IN DEMAND AS INDICATED BY VACANCIES REPORTED TO PLACEMENT BUREAUS

(27 Colleges and Universities)

Subjects	Average (Per Cent)	No Calls (No. of Schools)
Biology alone	21	5
Biology and general science	18	1
Biology and physical science	23	0
Biology and girl's P. E.	3	6
Biology and coaching	12	3
Biology and mathematics	7	3
Biology and social science	4	1
Biology and driver training	3	5
Biology and English	2	5
Biology and home economics	1	7

DISCUSSION AND RECOMMENDATIONS

On the basis of the results of the survey and in the interest of preparing teachers who are well prepared to teach biology in high schools, we make the following recommendations concerning the curricula for high school biology teachers:

1. *The curriculum should provide for a sufficient number of required specified courses in biological science.* In order to be well qualified to teach biological science the teacher needs as much preparation, perhaps more, than for the other sciences. It should be emphasized that not "just" anyone can teach biology or that a few courses in health, physical education, and agriculture provide adequate preparation. Examination of many recent high school biology textbooks will show the breadth of preparation needed. Memorizing the text materials will not provide the background needed for the teacher to interpret, demonstrate and explain fundamental biological concepts to the average high school student of today. Such preparation is also needed if the teacher is to help the superior student.

The curriculum should also include at least one course in field biology which would help him to lead field trips, to identify common animals and plants. It should include

some ecology which is essential for explaining problems related to conservation.

Biologists should promote a public relations program that will tend to off set the popular notion that a course in biology consists largely of dissecting frogs and pickled plants (or if it does, it is not a modern course), and that biology is a vital dynamic experimental science in which all the available tools of the physical sciences and mathematics are used. Biologists in the past have been too dependent upon the discoveries of the chemists and physicists to forge ahead on their own.

As long as biology is taught in many schools by coaches and others who have "minors" in biology consisting largely of courses in hygiene, kinesiology, and agriculture, non-laboratory survey courses, etc., biology cannot be expected to receive the respect and the interest from students that it deserves. The course content of high school biology courses should be carefully evaluated and the minimum laboratory facilities and equipment required should be listed. If biology can be taught in an ordinary classroom with a demonstration table and ordinary desks, a few aquaria and several broken-down microscopes, it cannot be expected to be considered as a science course—it becomes at best, a course in natural philosophy!

State departments of education and regional accrediting agencies should be asked to reconsider the type of preparation recommended for biology teachers and the minimum physical facilities and equipment needed in an accredited high school. This might require school administrators to look for well prepared biology teachers and to consider the science laboratory as important as the gymnasium, and science equipment as important as that for football, basketball and the marching band.

2. *The curriculum should be balanced and provide for preparation in both botany and zoology.* The beginning courses and the rest of the curriculum should include both botany and zoology. Botanists frequently complain that biology teachers have little or no background in the plant sciences. Examination of the catalogs of some colleges preparing teachers, especially the smaller ones, list none or only several courses in botany. We conclude that graduates of some colleges obtain no preparation in botany. Perhaps the biology departments of some smaller colleges emphasize pre-medical preparation and lack teachers well prepared in botany.

Wallen (1956) reported that one of the proposals of the Science Teaching Improvement Program of the A.A.A.S. is to assist colleges and universities and other institutions of higher learning in getting their science and mathematic departments to agree in their acceptance of teacher education as a major responsibility.

3. *Provision should be made for electives and to allow the student to concentrate in certain areas.* The curriculum should be planned so that students can take advanced courses in certain areas so that they can add depth to their preparation. Advanced courses in both botany and zoology should be available.

4. *The curriculum should include required courses in both chemistry and physics.* As Heller (1958) has so aptly stated, "The scientist of our new revolutionary era can no longer afford the 'tunnel vision' of the specialist of yesteryear. He must tear down the artificial barriers which used to prevent him from looking beyond his specialty into other fields."

At least one year of chemistry and physics should be required. In order to teach a modern course in biological science and to place it in its proper relation to the other sciences a background in the physical sciences is essential. Such topics as photosynthesis, metabolism, respiration, diffusion, digestion, the effects and use of radioisotopes, etc., can only be given adequate treatment by teachers who have had courses in the physical sciences. Such preparation will be helpful in setting up laboratory demonstrations, preparing chemical solutions, constructing apparatus, helping gifted students, and supervising student

projects for science fairs. A biology teacher today without preparation in the physical sciences is hopelessly handicapped! Many colleges and universities preparing high school biology teachers should plan to revise their curricula and have definite requirements in the physical sciences.

5. *The curriculum should include courses in mathematics and earth science.* Biology is becoming increasingly dependent upon mathematics, particularly biometry, as an aid in the interpretation of scientific data. A background in mathematics is essential.

Earth science, particularly geology and meteorology, are important in ecology and conservation. They are especially important for the general science teacher.

6. *The curriculum should be organized to permit the teacher to take graduate work so that he can earn an advanced degree in biological science.* The curriculum should have an "open end" and not be terminal. It should be organized so that the teacher can continue with graduate work and as a minimum, earn a Master's degree in the subject matter area that he teaches. Because of a lack of adequate preparation in science and mathematics he may be forced to earn a Master's degree in education. Most experienced science teachers need additional preparation in the subject matter that they teach rather than in *how* to teach.

Just as the demand for high school science teachers has increased, so has the demand increased for teachers in the colleges and universities. The Ph.D. is usually considered as essential for the college or university teacher. Data prepared by Maul (1955–57) shows that there has been a drop from 31.4 per cent in 1953–54 to 23.5 per cent in 1956–57 of new full-time college teachers who held the earned doctorate. For teacher's colleges the percentage dropped to 15.7 per cent. New college teachers holding less than the Master's degree increased from 18.2 per cent in 1953–54 to 23.1 per cent in 1956–57. Well qualified high school teachers who have well organized preparation as undergraduates and who earn the Master's degree in the biology sciences should be a potential source of college and university teachers. (See also, Myers and Crall, 1958.)

7. *The curriculum should be planned so that the student will qualify for the best available positions.* The curriculum and counselling program should be in harmony with the current calls for teachers in the area served. The beginning teacher frequently obtains his first position in a small high school and is often expected to teach general science. The data in Table II obtained from the Placement Bureaus of 27 colleges shows that approximately 18 per cent of the calls are for biology teachers qualified to teach general science. In the authors' institution nearly 50 per cent of the vacancies reported are in combination with general science, and fewer than 5 per cent of the vacancies reported are in combination with English, social science, home economics, driver training and music. Majors in the biological sciences are strongly advised to elect minors in the physical sciences as this is one of the most frequent combinations requested with biology. This is not difficult as one year of chemistry and one year of physics are required in the curriculum for biology majors.

Another consideration should be for those who for various reasons do not qualify as competent and successful teachers. A strong background in science may enable them to obtain a good position in industry or government service.

However, the authors' have heard it suggested that if biology teachers obtain broad preparation in science they may be offered higher paying positions in industry or government service and thus be lost to the teaching profession. This implies that teachers should be prepared so that they have no choice but to teach. It should be emphasized that science teachers are not missionaries and that they deserve a remuneration that will make teaching as financially attractive as other professions requiring equivalent preparation. If sufficient numbers of adequately prepared science teachers are available we should be

able to locate and prepare the technicians and scientists that we need to compete successfully with the Soviet Union.

Biologists are disturbed that the government does not offer them salaries equivalent to those of chemists, physicists, and engineers. Actually a considerable number of physical scientists are employed in laboratories to do biological research, but largely because biologists often do not have adequate preparation in the physical sciences and mathematics. A biologist with sufficient preparation in chemistry can receive the higher increments and probably would replace chemists working on biological problems. A colleague has suggested that a research organization finds it easier for a chemist to learn enough biology to do biological research than it is for a biologist to learn enough chemistry!

SUMMARY AND RECOMMENDATIONS

1. Questionnaires were sent to 90 colleges and universities, mostly teachers' colleges and state colleges, to determine their curriculum requirements for the preparation of high school biology teachers. This included requirements in botany, zoology, total biological sciences, chemistry, physics, geology, mathematics, and foreign language.

2. Replies were received from 64 colleges and universities. Seven did not prepare biology teachers.

3. The replies from the 57 schools included in the sample indicated that more than one-third (20) do not require any chemistry, physics or mathematics, over one-third (23) do not require any chemistry, that over one-half (32) do not require any physics, and about two-thirds (41) do not require any mathematics. Fifty-one of the 57 do not require any foreign language.

4. Questionnaires were also sent to the Placement Bureaus of the same 90 colleges and universities.

5. Replies were received from 40 colleges and universities. Thirteen did not prepare biology teachers.

6. The replies indicated that most vacancies reported were for teachers prepared to teach biology alone (21 per cent), in combination with general science (18 per cent), physical science (28 per cent), and coaching. Over 60 per cent of the vacancies were for biology alone or in combination with general science and physical science.

7. It is recommended that the curriculum for teachers of biological science be organized to require:

a. Broad preparation in the biological sciences, including both botany and zoology, and field biology.

b. Areas of concentration (depth in the biological science).

c. One year of physics and one year of chemistry.

d. Mathematics and earth science.

e. That the curriculum be organized so that the student may take graduate work and earn a Master's degree in a biological science (or at least a major if the Master's degree is in Education).

f. That the curriculum be organized so that the student will qualify for the teaching positions for which there is the greatest demand.

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